

Attorney's Docket No. 38190/267786

**PATENT**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re: Edward Litwinski, Rahmatollah F. Toosky Confirmation No.: 9632  
Appl. No.: 10/631,907 Group Art Unit: 3677  
Filed: July 31, 2003 Examiner: Flemming Saether  
For: RIVETS HAVING HIGH STRENGTH  
AND FORMABILITY

March 31, 2005

Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450

**DECLARATION UNDER 37 C.F.R. § 1.131**

Sir:

We, Edward Litwinski and Rahmatollah F. Toosky, hereby declare and state that:

1. We are the inventors of the claimed invention of the above-identified U.S. Patent Application Serial No. 10/631,907.
  
2. On or before October 23, 2001, we produced and tested slug rivets as described below, thereby reducing to practice our invention as described and claimed in the subject application, which is generally directed to a method of manufacturing rivets having high strength and formability. Attached as Exhibit A is a copy of a data summary sheet and four graphs as evidence of our reduction to practice before October 23, 2001. Each of the four graphs illustrates stress versus strain characteristics of two specimens prepared according to the present invention, and the data summary sheet includes the test results for all of the eight specimens. The test specimens were produced by (a) providing a plate of aluminum alloy, (b) friction stir welding a portion of the plate to form a refined grain structure in the portion of the plate, (c) cutting a strip-shaped blank from the refined portion of the plate, (d) machining the blank to form a cylindrical rod, and (d) cutting the

In re: Edward Litwinski, Rahmatollah F. Toosky

Appl. No.: 10/145,342

Filed: May 14, 2002

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rod at successive increments along its length to form a plurality of cylindrical specimens, each specimen having the cylindrical shape of a slug rivet. During testing, each specimen was loaded into a fixture defining a cylindrical orifice such that a portion of the specimen extended from the orifice. The extending portion was then compressed toward the fixture, thereby deforming the extending portion to form a head having a diameter greater than the rest of the specimen. A copy of the deformed specimens appears on each graph of the shear test results. (The deformed specimens are disposed in the orifices of the fixtures.) Each of the tests was conducted prior to October 23, 2001, and the four graphs were also prepared before that date. Photographs of the same specimens are included in Appendix B. The photographs were taken after October 23, 2001. The test results are also described on page 3 of the invention disclosure, which is attached as Exhibit C. The invention disclosure was prepared and witnessed prior to October 23, 2001. Dates, personal information, and other information not relevant to the substantiation of invention have been redacted from the copies included in Appendices A and C.

3. We hereby declare that all statements made herein of our own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application of any patent issued thereon.



Edward Litwinski

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Rahmatollah F. Toosky

In re: Edward Litwinski, Rahmatollah F. Toosky  
Appl. No.: 10/145,342  
Filed: May 14, 2002  
Page 2 of 2

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Edward Litwinski

Rahmatollah F. Toosky

CLTO1/4700567v1

# MECHANICAL PROPERTIES TESTING LABORATORY.

SHEET / OF /  
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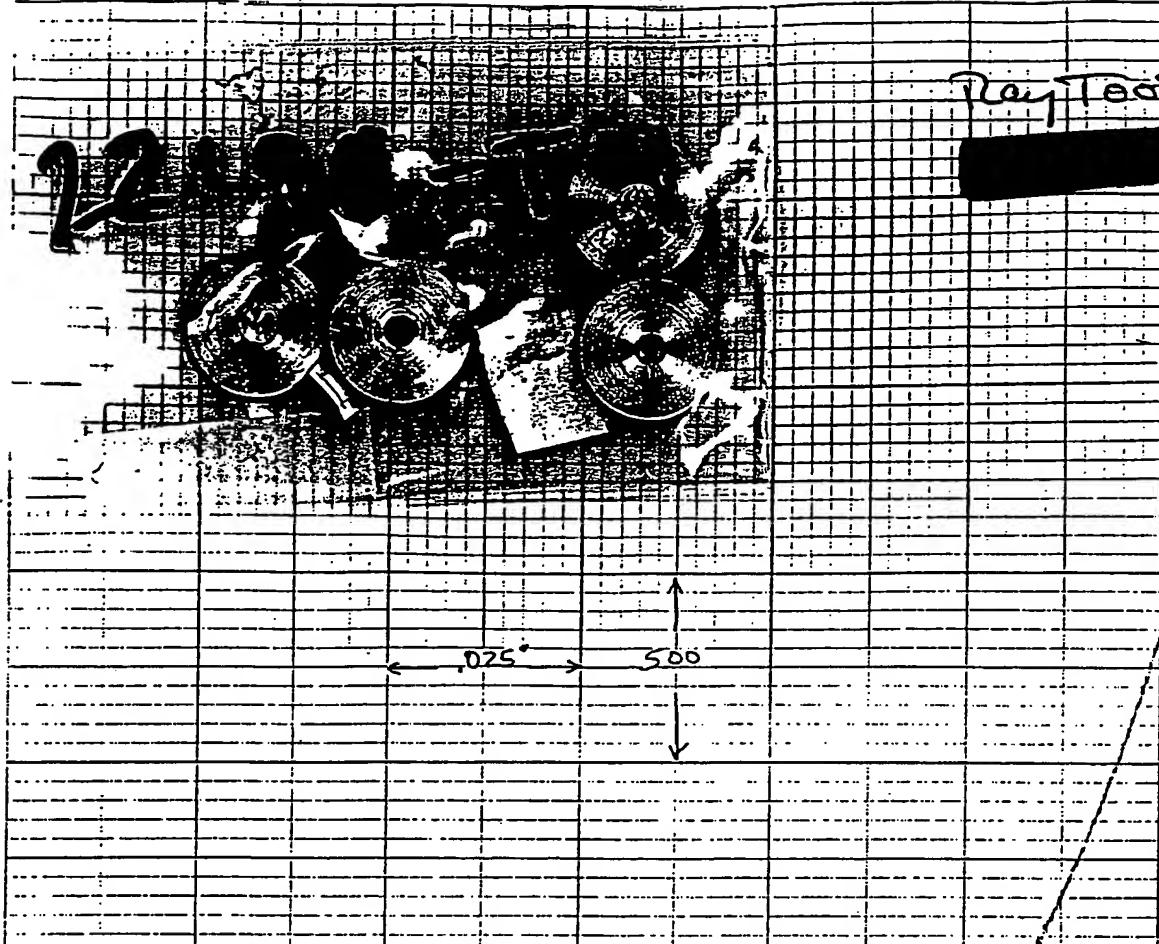
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**DATA AND RESULTS CHECKED**

DATE

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Ray Teesky

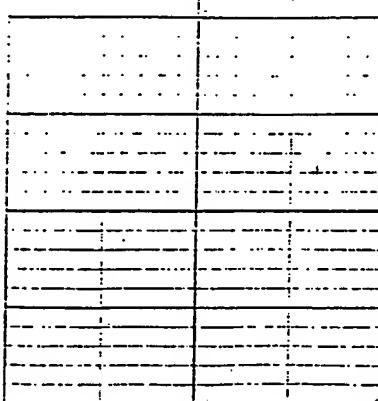


2219-T4

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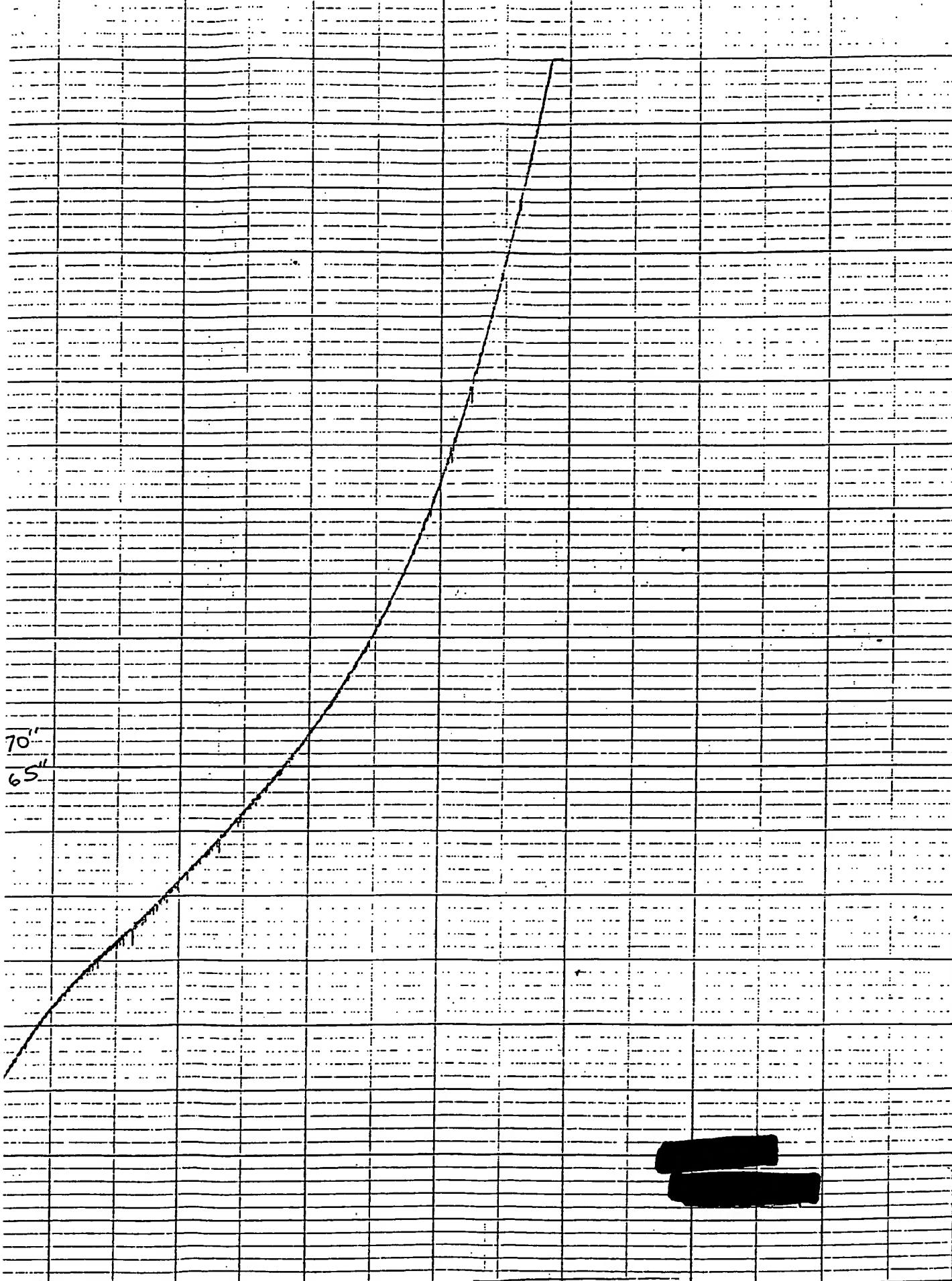
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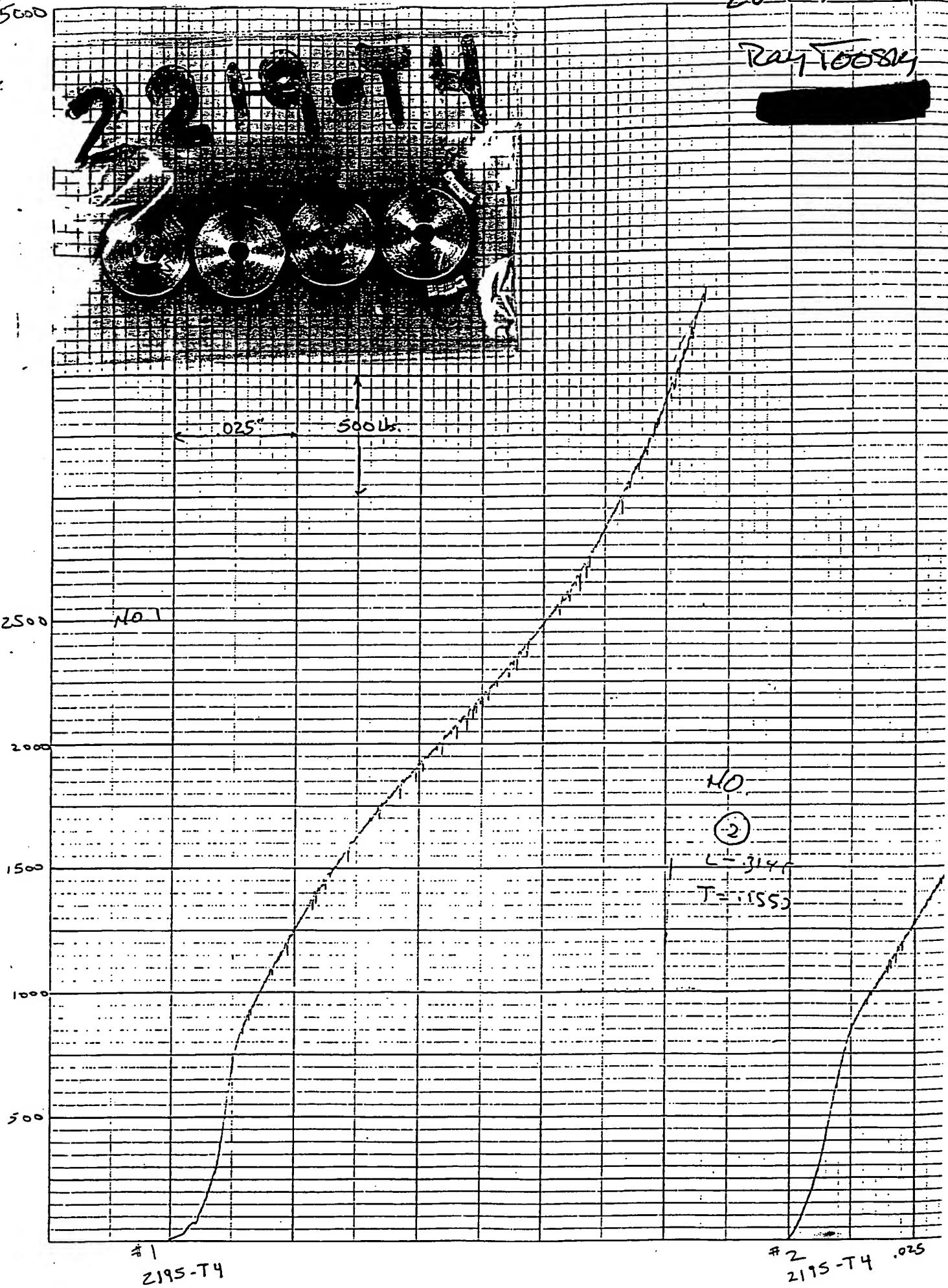


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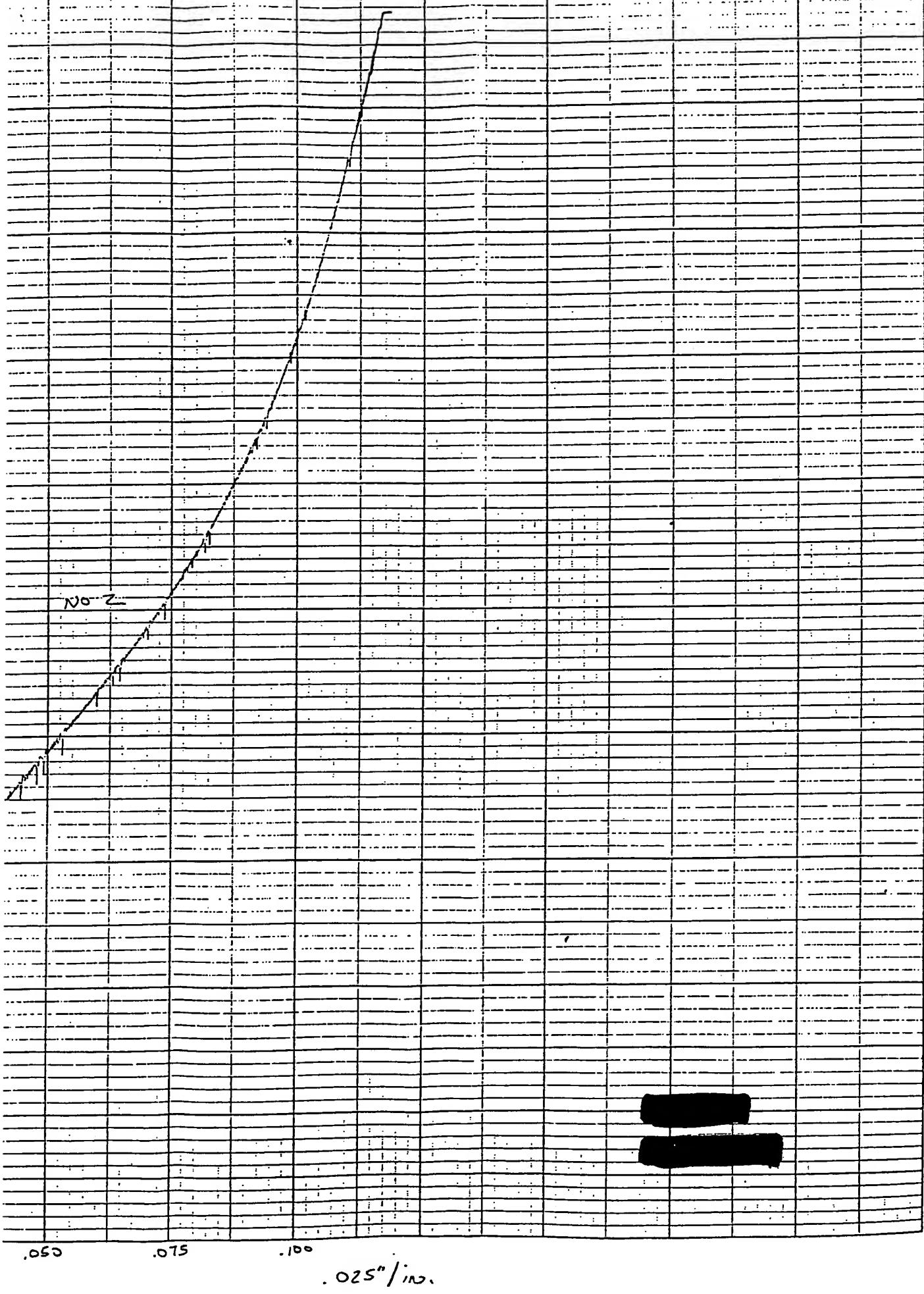
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No. 2



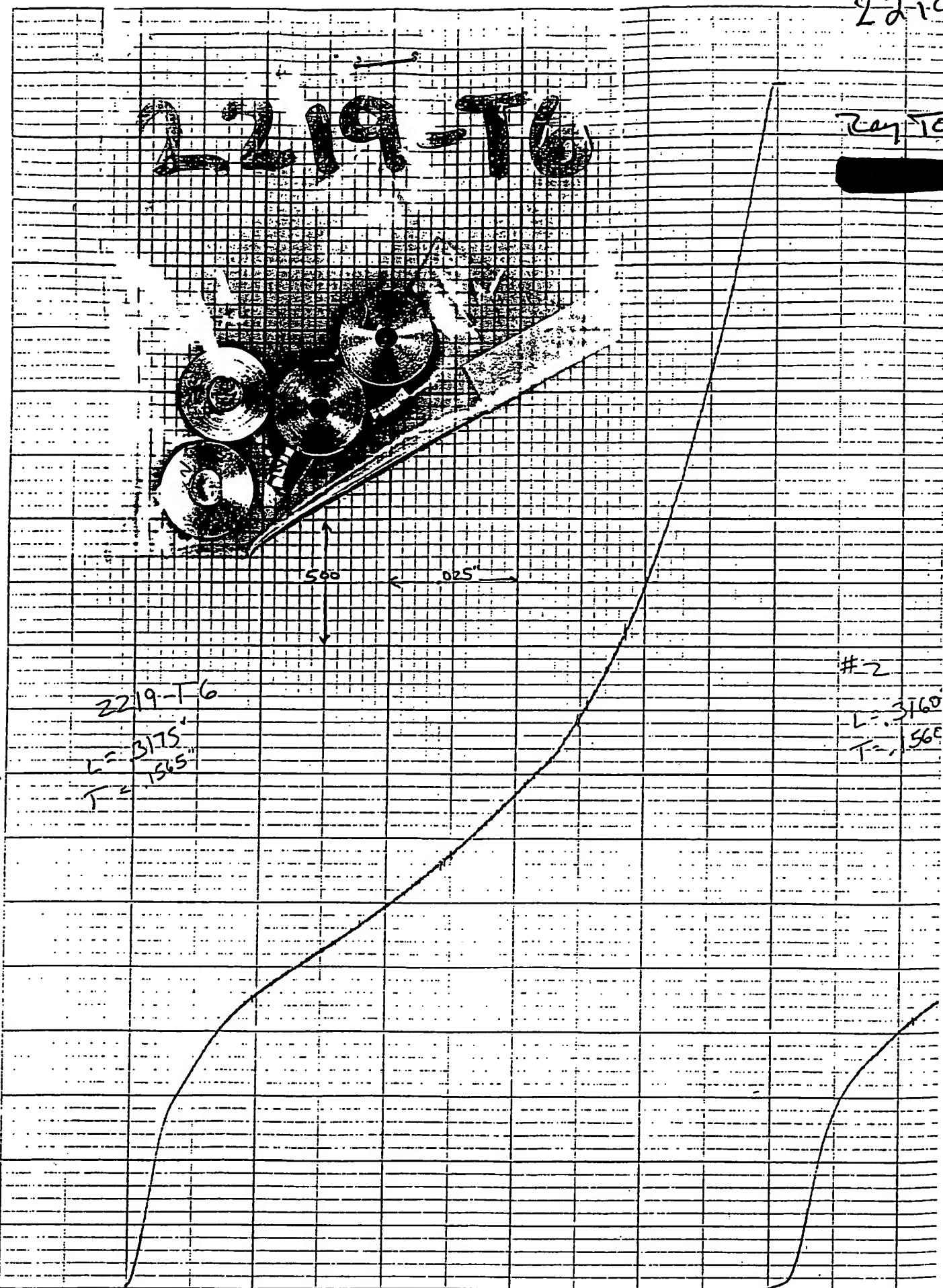
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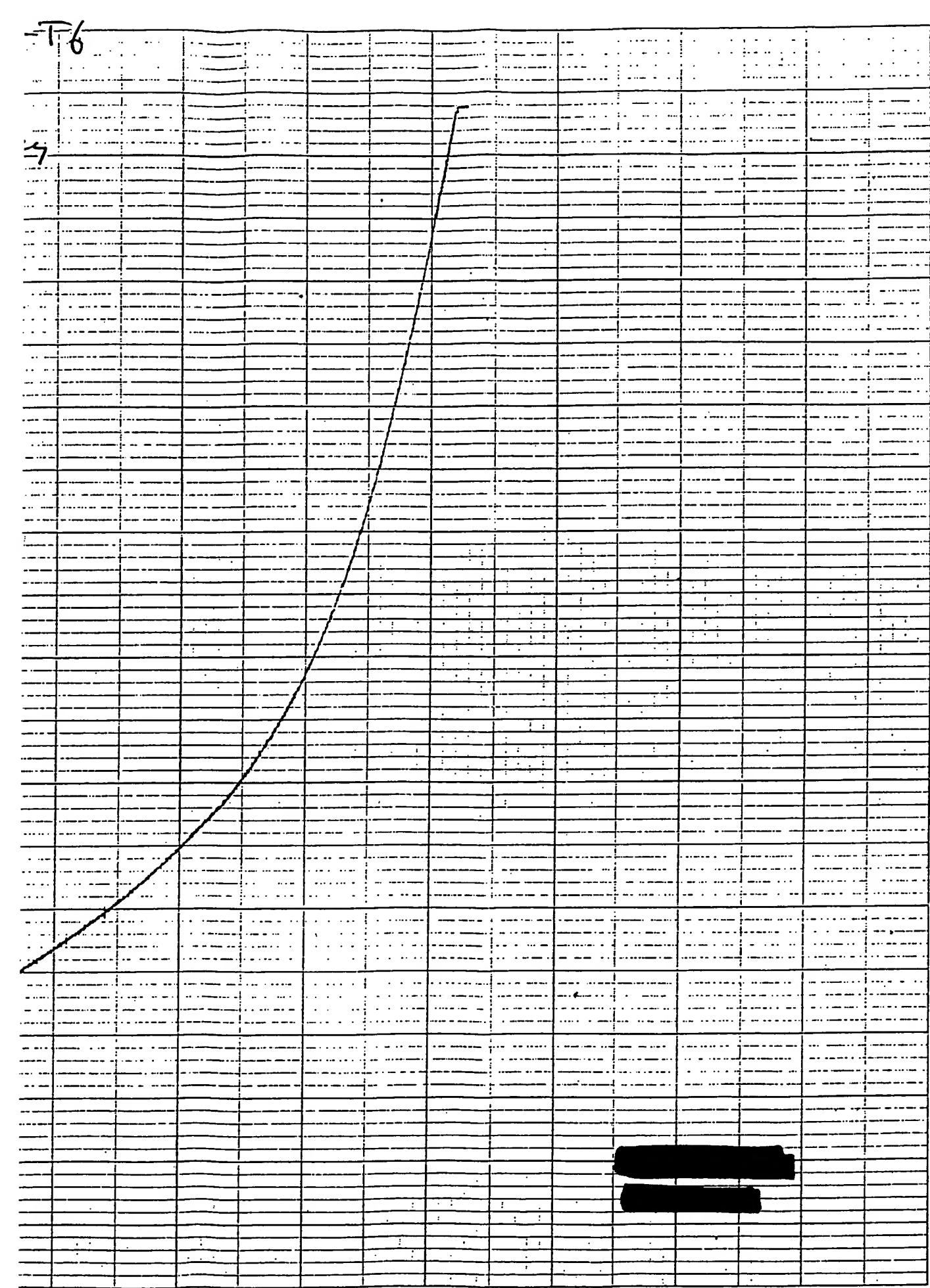
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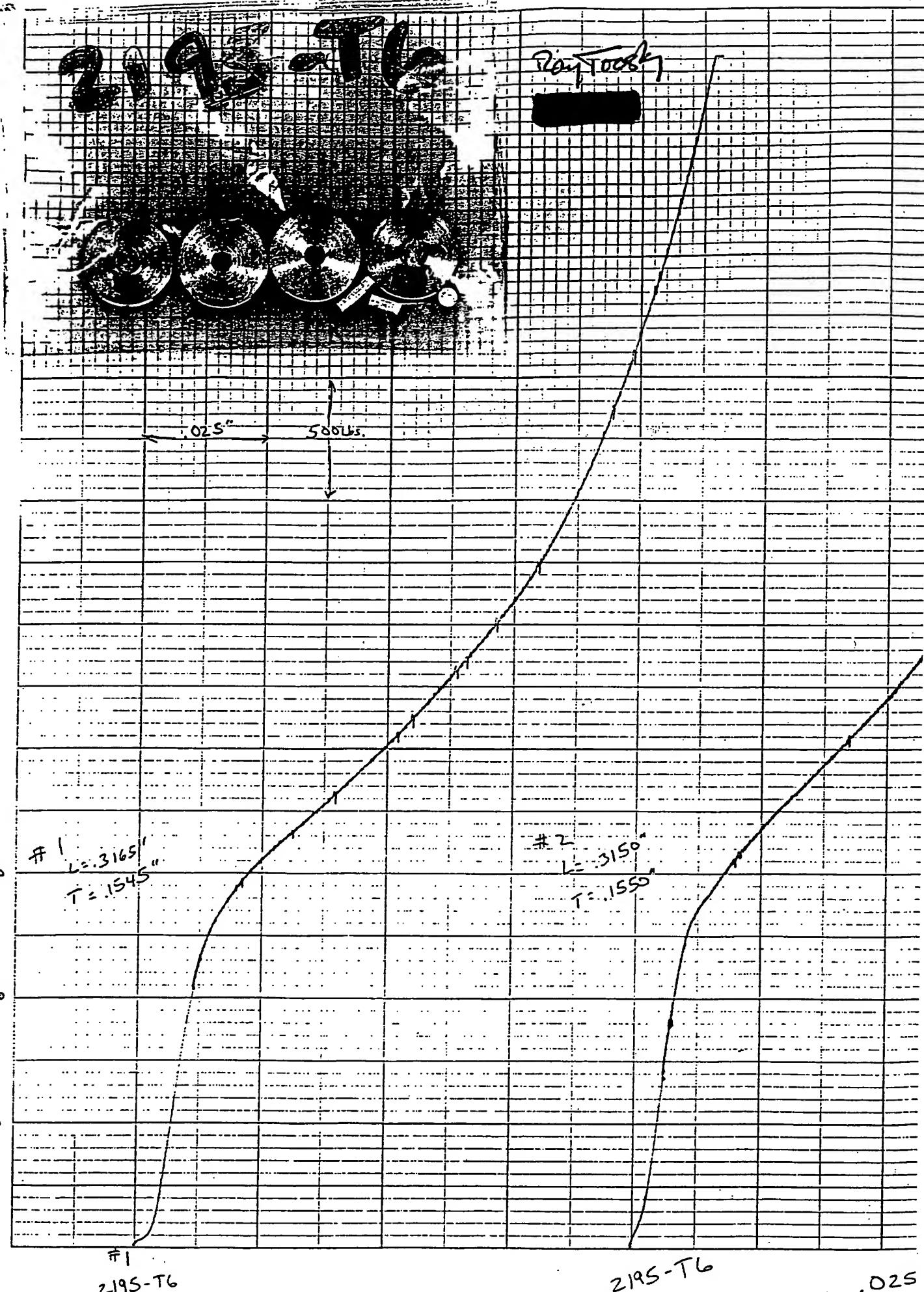
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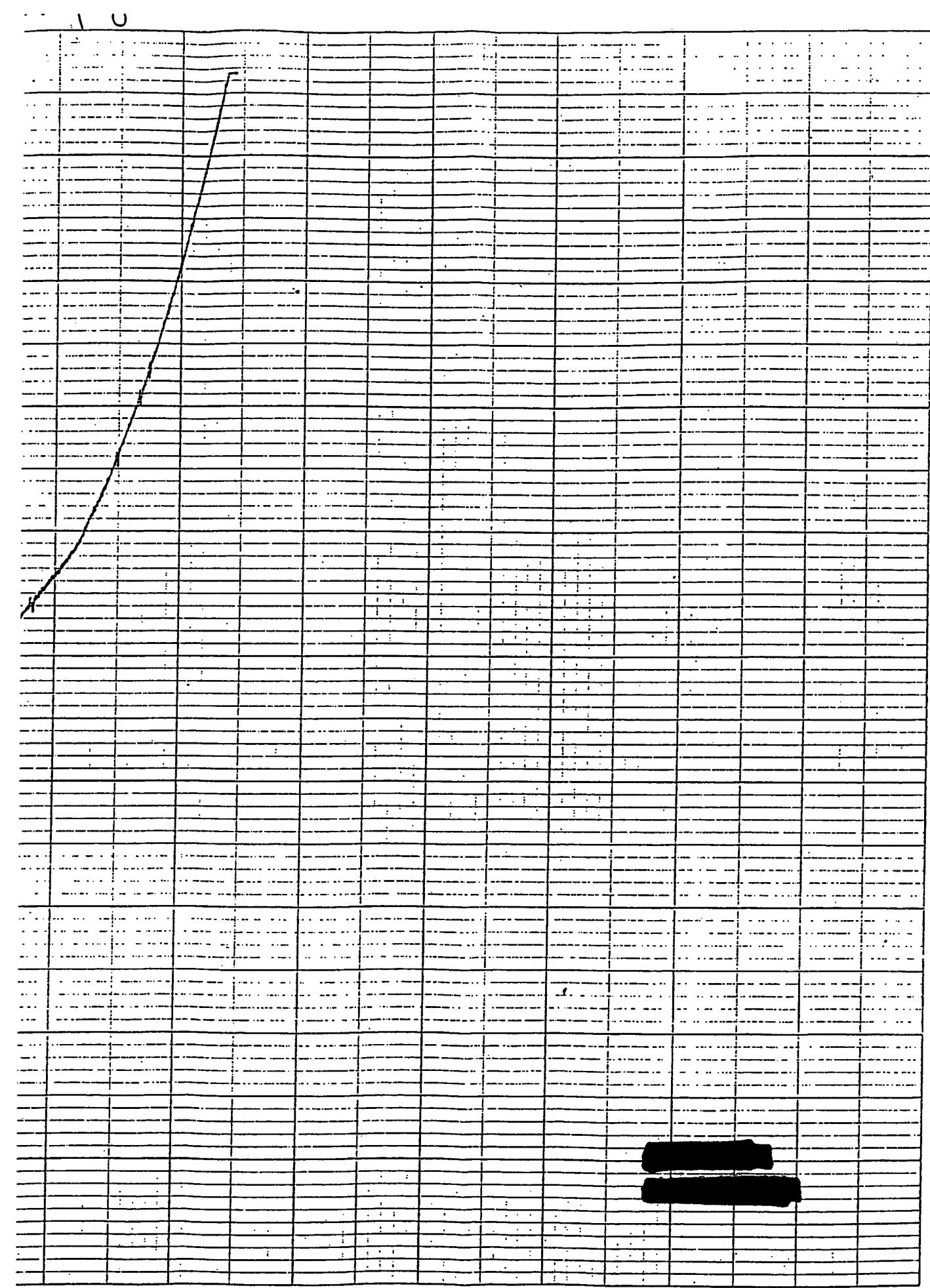


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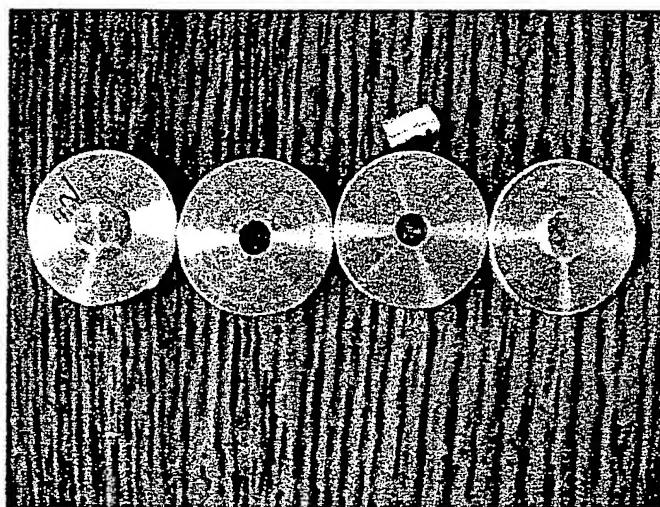
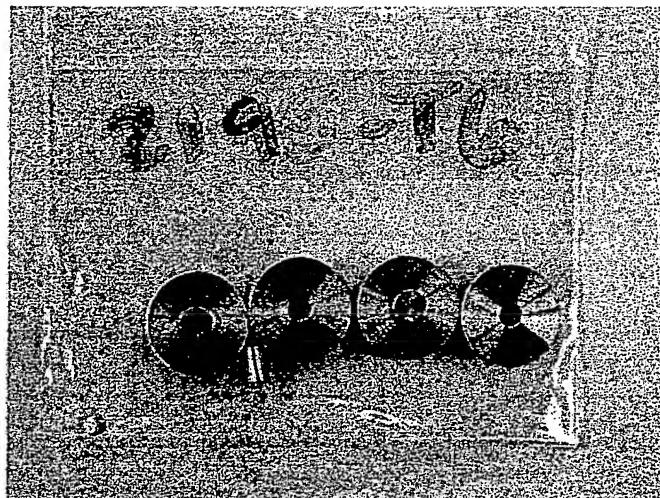
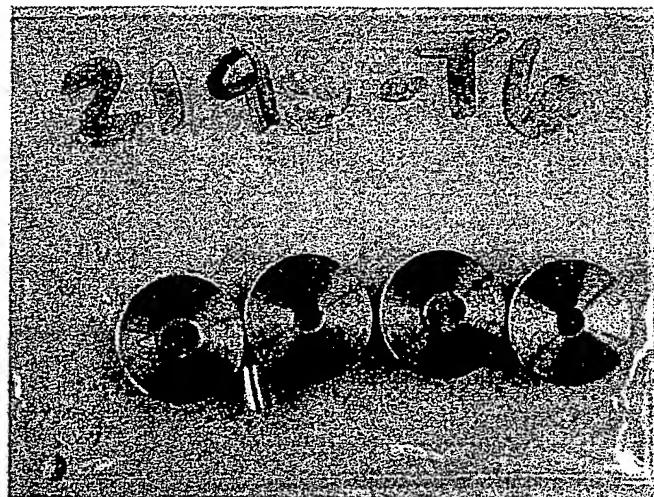
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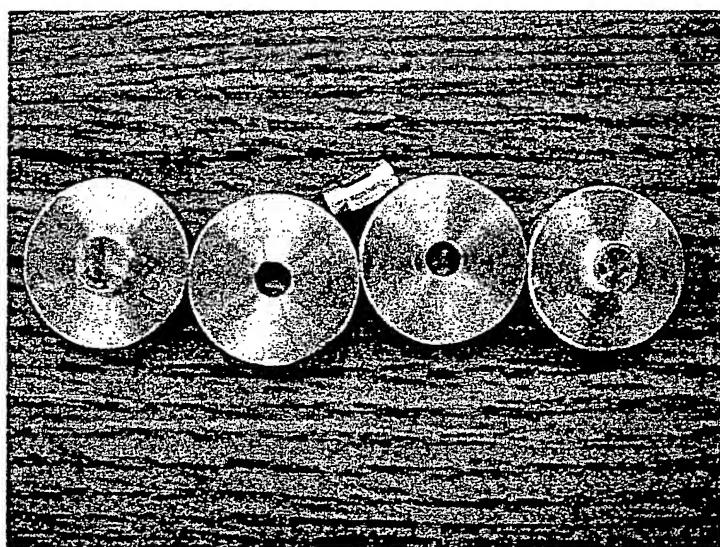
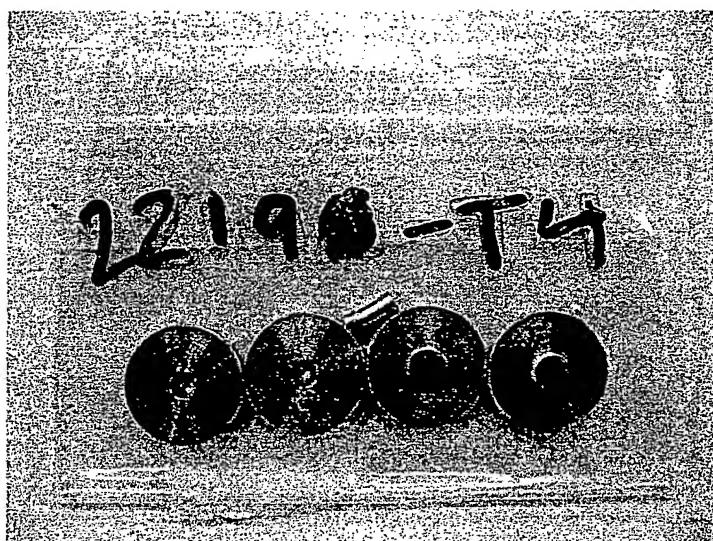
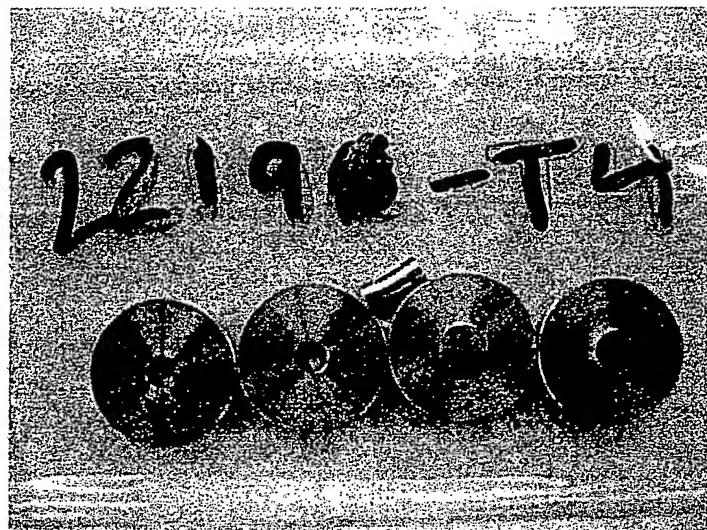




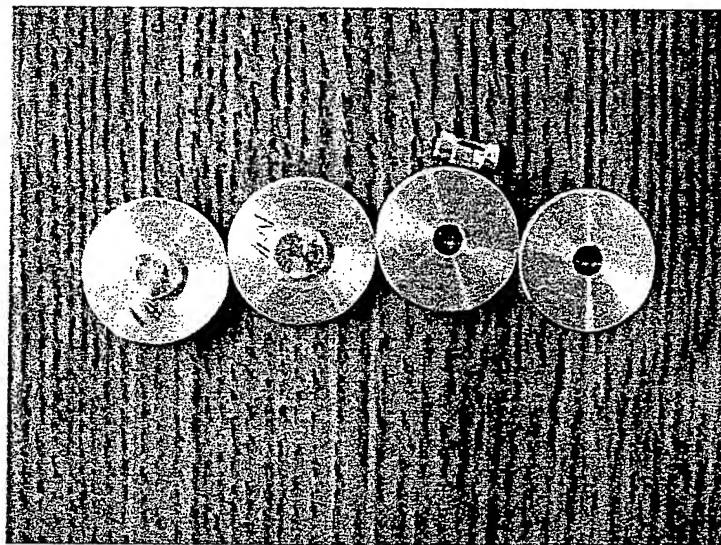
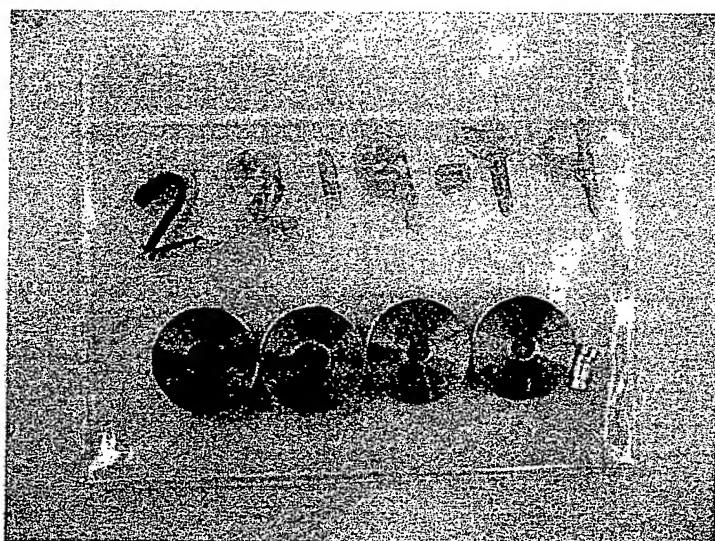
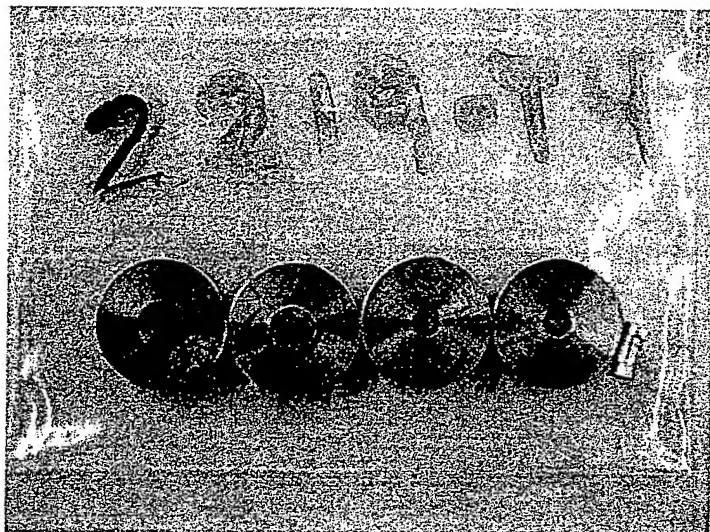
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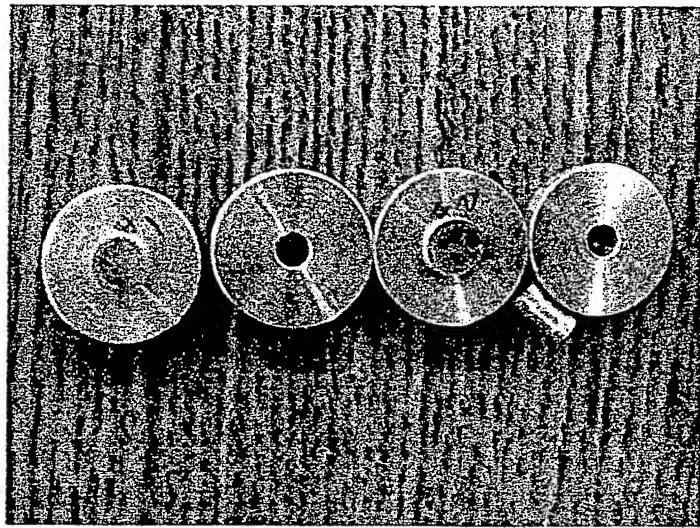
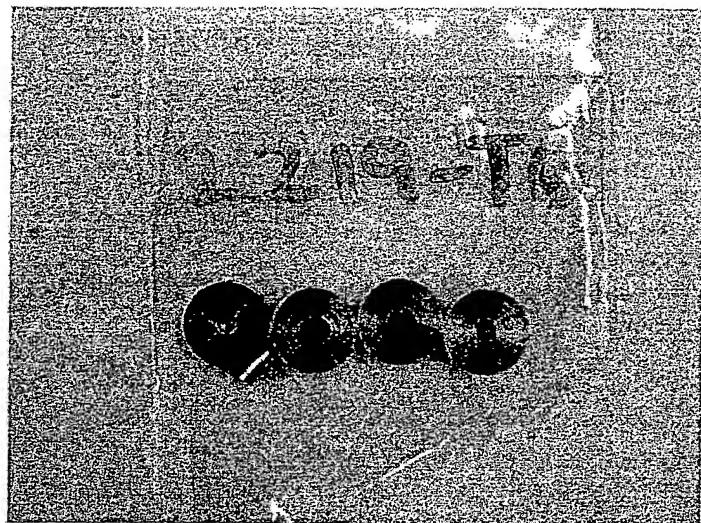
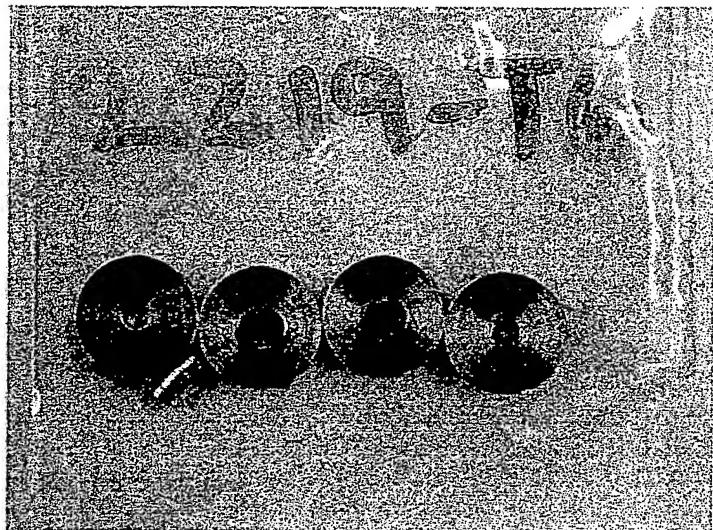
**22196-T4**



**2219-T4**



**2219-T6**





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## INVENTION DISCLOSURE

Page 1 of \_\_\_\_\_

This form is to be used for disclosure to The Boeing Company of inventions, discoveries, improvements or innovations, whether or not considered patentable.

See above for instructions.

A		TITLE OF INVENTION (Descriptive and Concise)					
		Super Plastic Rivet Material.					
INVENTOR INFORMATION (Use Additional Sheet If Necessary)							
INVENTOR NAME (FIRST, M.I., LAST) <b>1</b>		INVENTOR NAME (FIRST, M.I., LAST) <b>2</b>		INVENTOR NAME (FIRST, M.I., LAST) <b>3</b>		INVENTOR NAME (FIRST, M.I., LAST) <b>4</b>	
Edward Litwinski		Rahmat F. Toosky					
SOCIAL SECURITY NO.		SOCIAL SECURITY NO.		SOCIAL SECURITY NO.		SOCIAL SECURITY NO.	
ORG. NO.	MAIL STOP	ORG. NO.	MAIL STOP	ORG. NO.	MAIL STOP	ORG. NO.	MAIL STOP
PHONE		PHONE		PHONE		PHONE	
B							
BOEING EMPLOYEE (ADD SUBSIDIARY)		BOEING EMPLOYEE (ADD SUBSIDIARY)		BOEING EMPLOYEE (ADD SUBSIDIARY)		BOEING EMPLOYEE (ADD SUBSIDIARY)	
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MANAGER'S NAME C.E. Silverman PHONE		MANAGER'S NAME C.E. Silverman PHONE		MANAGER'S NAME		MANAGER'S NAME	
STATE OF DEVELOPMENT (See Remarks On Back)							
C DATE CONCEIVED		CONCEPT ONLY PROVEN ANALYTICALLY DESIGN COMPLETE	DATE BUILT	DATE SATISFACTORILY TESTED	PROTOTYPE IN PRODUCTION	DATE	
D APPLICATION OF THE INVENTION							
PRODUCT/PROGRAM All riveted aluminum products				PRODUCTION RELEASE E.G. PRR NO.			DATE
D POTENTIAL CUSTOMER(S) IN ADDITION TO BOEING							
E DISCLOSURE OF INVENTION OUTSIDE BOEING							
DISCLOSED TO: <input type="checkbox"/> VENDOR <input type="checkbox"/> CUSTOMER <input type="checkbox"/> OTHER		NAME(S) None at this time				DATE(S)	
F PUBLISHED <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO		PUBLICATION NAME			DATE	VOLUME NO.	PAGE
G DEVELOPMENT HISTORY							
1. WHAT BOEING ACCOUNT OR WORK ORDER WERE YOU CHARGING TO WHEN YOU MADE THIS INVENTION? ACCOUNT OR WORK ORDER NO. FOR EACH INVENTOR (16-DIGIT CHARGELINE) 1) Personal Time 2) _____ 3) _____ 4) _____							
2. CHECK AS APPLICABLE: <input type="checkbox"/> THIS INVENTION WAS CONCEIVED OR FIRST BUILT AND TESTED IN THE COURSE OF WORK UNDER A U.S. GOVERNMENT CONTRACT. CONTRACT NO. OR OTHER IDENTIFICATION _____ <input checked="" type="checkbox"/> THIS INVENTION WAS NEITHER CONCEIVED NOR FIRST BUILT AND TESTED IN THE COURSE OF WORK UNDER A U.S. GOVERNMENT CONTRACT. <input type="checkbox"/> THE FOLLOWING ADDITIONAL PARTIES MAY HAVE RIGHTS TO THIS INVENTION: _____							
3. RELATED INVENTION DISCLOSURE NOS.: _____							

DO NOT WRITE BELOW THIS LINE

DISCLOSURE NO.	DATE RECEIVED	DISCLOSURE ASSIGNED TO:	PE	IP
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**Introduction:** Briefly introduce the subject associated with your invention.

Due to a lack of formability of high strength aluminum alloys in the hardened condition, a rivet manufacturing requires forming the rivet head in a soft condition, heat treating the rivet. Although there are a wide range of material issues associated with rivet material selection, the predominant factors are the materials bucking ability (formability) and the shear strength. There are many aluminum alloys with desirable shear strength, however, they tend to fracture during installation.

The friction stir weld process produces an ultra fine grain structure in the "nugget" area of the weld. Testing had determined that this nugget material has superior formability. Formability is known to be dependant on grain size. For example, as an indication of formability, the typical elongation of 2219-T4 is 20%. The elongation for 2219-FSW material was measured up to 29% and the 2195-FSW material was measured up to 21.5%. The increase in % elongation means an increase in formability of an alloy. This also applied to aluminum alloys with directional properties, for example the 2195 alloy, that have a lack of formability. Additional benefits include increased fatigue life, corrosion resistance and fracture toughness that should be applicable to all aluminum alloys, i.e. 2219, 2195, 7050, 7075 and 2017.

**Problem Solved By This Invention:** State the existing problem that is solved by your invention.

**Response:** The rivet manufacturing process can be shortened using fine-grain material instead of an annealed material. The rivet would be used in the "as-formed" condition. This would reduce the rivet manufacturing costs as well as eliminating the possibility of rivets being heat treated improperly.

Additionally, conventional mill products have limited formability, toughness and corrosion resistance. Lack of formability results in rivet cracking during forming operations. A lack of fatigue strength results in rivet fatigue cracks while in service. A lack of corrosion resistance results in premature failure.

**Background:** Describe the approaches that are currently used to solve or mitigate the existing problem. Additionally, describe the shortcomings associated with these approaches. Include any related patents or publications that you have knowledge of.

**Response:** Softer, lower strength material have been used to avoid cracking. The dimension or upset of the head is controlled to reduce cracking.

The rivets are typically coated for improved corrosion resistance.

**Invention Description:** Provide a detailed description of your invention, and illustrate it in a drawing, sketch, or a schematic (if susceptible to illustration). Correlate the illustration with the description by

THE FOREGOING WAS EXPLAINED TO AND UNDERSTOOD BY ME				INVENTOR(S) SIGNATURE		
WITNESSES SIGNATURES (AT LEAST TWO)	DATE	ORG. NO.	MAIL STOP	FIRST	M.I.	LAST
SIGN <i>Kevin Ruth</i>				SIGN <i>Edward Litwak</i>		
PRINT Kevin Ruth	PHONE			PRINT <i>Rahmat Tooki</i>		
SIGN <i>Daryl Hamill</i>				SIGN		
PRINT <i>Rudy Laureta</i>	PHONE			SIGN		
DISCLOSURE NO. (ASSIGNED BY PATENT STAFF)		DATE RECEIVED				

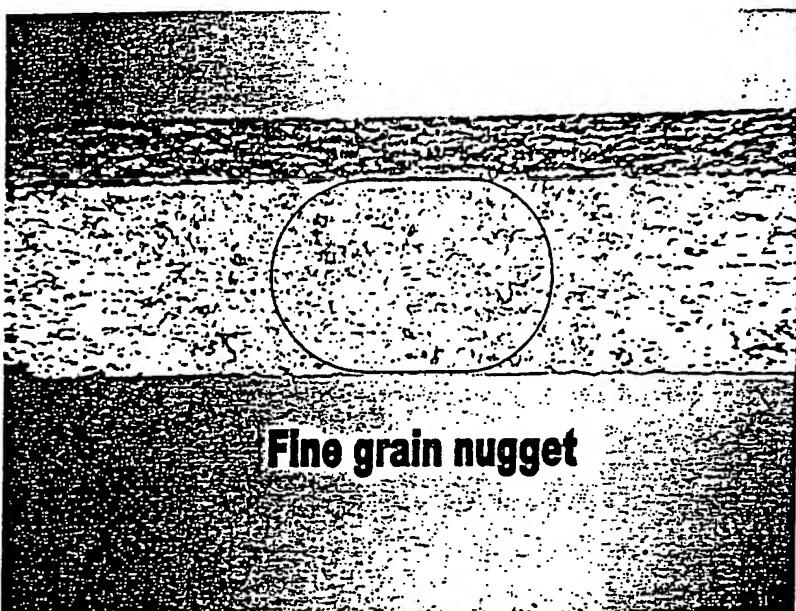
## BOEING PROPRIETARY

using reference numerals and/or letters. Most importantly, clearly state the novelty of your invention (to the best of your knowledge). The invention description is likely to require more than one page of information.

Response: Testing had determined that the FSW nugget material has superior characteristics as a rivet material, such as increased toughness, increased fatigue life and increased corrosion resistance.

A load vs. displacement compression curve of 2219 and 2195 -T6 FSW nugget materials illustrated that these materials had much greater formability than materials presently produced.

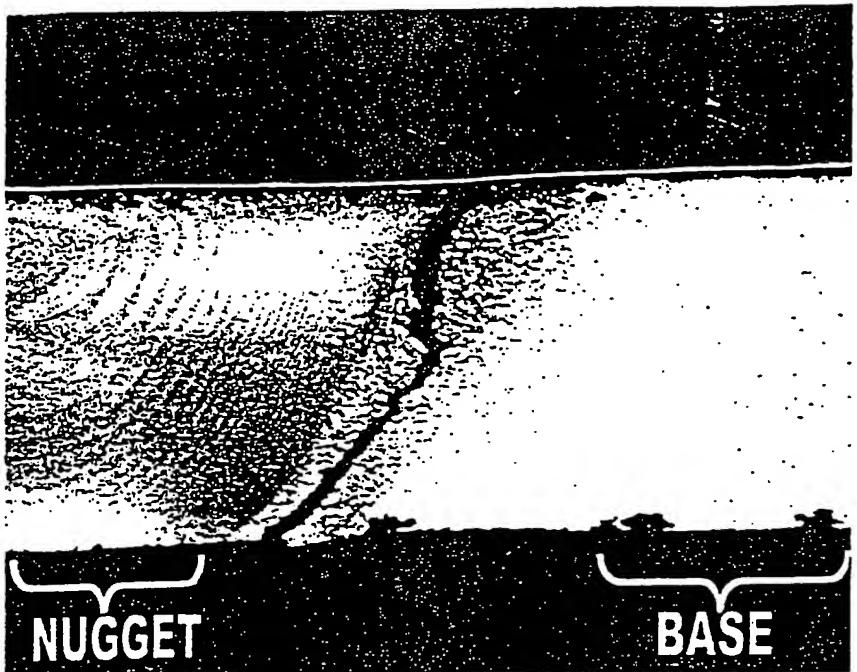
Corrosion testing of a FSW specimen had determined that the nugget was less susceptible to corrosion than the base material. A cross section through a 2219-T6 tensile specimen that had been previously exposed to 90 days of alternate immersion testing determined that the nugget area had the least amount of corrosion attack. The maximum depth of pitting and intergranular attack in the unaffected base metal was twice as deep as the nugget material.



Overall view of 2219 tensile specimen after 90 days of alternate immersion testing. Circle indicates nugget area.

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SIGN <i>Kevin Ruth</i>	PHONE [REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	SIGN <i>Edmund O'Leary</i>		[REDACTED]	[REDACTED]
PRINT Kevin Ruth					SIGN <i>Edmund O'Leary</i>		[REDACTED]	[REDACTED]
SIGN <i>Duffy Gaultier</i>	PHONE [REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	SIGN <i>Edmund O'Leary</i>		[REDACTED]	[REDACTED]
PRINT <i>Duffy Gaultier</i>					SIGN <i>Edmund O'Leary</i>		[REDACTED]	[REDACTED]
SIGN <i>Ruth Lauretta</i>	PHONE [REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]	SIGN <i>Edmund O'Leary</i>		[REDACTED]	[REDACTED]
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View of cross section through 2219-T6 FSW tensile specimen (after testing). Note the area annotated as the nugget area has less corrosion as the base metal.



Detailed view of nugget metal corrosion.



Detailed view of base metal corrosion.

**Technical Maturity:** What is the state of development? Provide evidence that your invention concept has been sufficiently developed that there is little technology risk associated with its implementation. Results from analysis, simulation/modeling, or prototype testing are preferred.

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SIGN <i>Kevin Ruth</i>	PHONE [REDACTED]	[REDACTED]			SIGN <i>Edward Othieno</i>			[REDACTED]
PRINT Kevin Ruth					SIGN <i>Rahmat J. Took</i>			[REDACTED]
SIGN <i>Paul G. Hettler</i>	PHONE [REDACTED]	[REDACTED]			SIGN			
PRINT Rudy Lauretha					SIGN			
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Response: Bucking ability on 2219 and 2195 FSW nugget materials determined that they had a desirable "upsetting" characteristics far beyond the traditional rivet materials. The tests showed that the rivets also had good hole filling characteristics and shear strength.

**Technical Value:** Provide evidence that your invention represents a significant advance in a technology area important to the success of Boeing, whether or not currently used. Quantitative data, such as trade study results, supporting the claimed benefits of your invention are preferred.

Response: Boeing is a major aerospace user of riveted products. The use of superior rivets will favorably affect the quality of our products. The formability and material properties is a significant improvement in the alloy without any weight gain. The ultra fine grained rivet material can be substituted for conventional rivet alloys without requiring a drawing changes. Present specifications permit this.

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PRINT	Kevin Ruth [REDACTED]				SIGN	<i>Samuel Woods</i>	[REDACTED]	
SIGN	<i>Patty Shatto</i>	[REDACTED]			SIGN			
PRINT	Patty Shatto [REDACTED]				SIGN			
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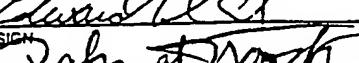
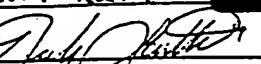
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## BOEING PROPRIETARY

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[REDACTED]

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SIGN		[REDACTED]			SIGN			
PRINT	Rudy Lauretta	[REDACTED]			SIGN			
DISCLOSURE NO. (ASSIGNED BY PATENT STAFF)				DATE RECEIVED				

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To: Ed Litwinski  
Rahmat F. Toosky

Mail: [REDACTED]

Subject: Boeing Invention Disclosure No. [REDACTED] "Highly Deformable, High Strength Rivet Material"

\*\*\*\*\*PERSONAL INFORMATION\*\*\*\*\*

Full Name: RAHMATULLAH F. TOOSKY

Social Security Number: [REDACTED] Orgn \_\_\_\_\_ M/S \_\_\_\_\_

Work Phone: [REDACTED] Home Phone: [REDACTED]

Home Address: [REDACTED]

City: [REDACTED] County: [REDACTED]

State: [REDACTED] Zip Code: [REDACTED]

Country: [REDACTED] Citizenship: [REDACTED]

Mailing Address:  
(if different) \_\_\_\_\_

Employee Type: Salaried: \_\_\_\_\_ Hourly: \_\_\_\_\_ Non-Boeing \_\_\_\_\_

Company (if Non-Boeing) \_\_\_\_\_

\*\*\*\*\*ADDITIONAL INFORMATION (if known and appropriate)\*\*\*\*\*

1. Actual or projected date of first use by Boeing or others:

2. Actual or projected date of publication (outside of Boeing) of concepts or other information relating to the invention:

3. Useful descriptive materials (documents, drawings, test results, etc.);

see Attachment of Test DATA

Copy included  Will furnish upon request

[REDACTED]  
(Date)

Rahmat Toosky  
(Signature)

IP GROUP INTERNAL ROUTING

- 1 copy of completed form to U.S. Patent Administrator
- 1 copy of completed form to Patent Engineering
- 1 copy of completed form plus any attachments to outside law firm, if applicable

To: Ed Litwinski  
Rahmat F. Toosky

Mail: [REDACTED]

Subject: Boeing Invention Disclosure No. [REDACTED] "Highly Deformable, High Strength [REDACTED] PROPERTY  
[REDACTED]  
[REDACTED] SEAL BEACH, CA

\*\*\*\*\*PERSONAL INFORMATION\*\*\*\*\*

Full Name: Edward Litwinski

Social Security Number: [REDACTED] Orgn. [REDACTED] M/S [REDACTED]

Work Phone: [REDACTED] Home Phone: [REDACTED]

Home Address: [REDACTED]

City: [REDACTED] County: [REDACTED]

State: [REDACTED] Zip Code: [REDACTED]

Country: [REDACTED] Citizenship: [REDACTED]

Mailing Address:  
(if different) [REDACTED]

Employee Type: Salaried: \_\_\_\_\_ Hourly: \_\_\_\_\_ Non-Boeing \_\_\_\_\_

Company (if Non-Boeing) \_\_\_\_\_

\*\*\*\*\*ADDITIONAL INFORMATION (if known and appropriate)\*\*\*\*\*

1. Actual or projected date of first use by Boeing or others:

[REDACTED]

2. Actual or projected date of publication (outside of Boeing) of concepts or other information relating to the invention:

[REDACTED]

3. Useful descriptive materials (documents, drawings, test results, etc.);

see attachments

Copy included

Will furnish upon request

[REDACTED]  
(Date)

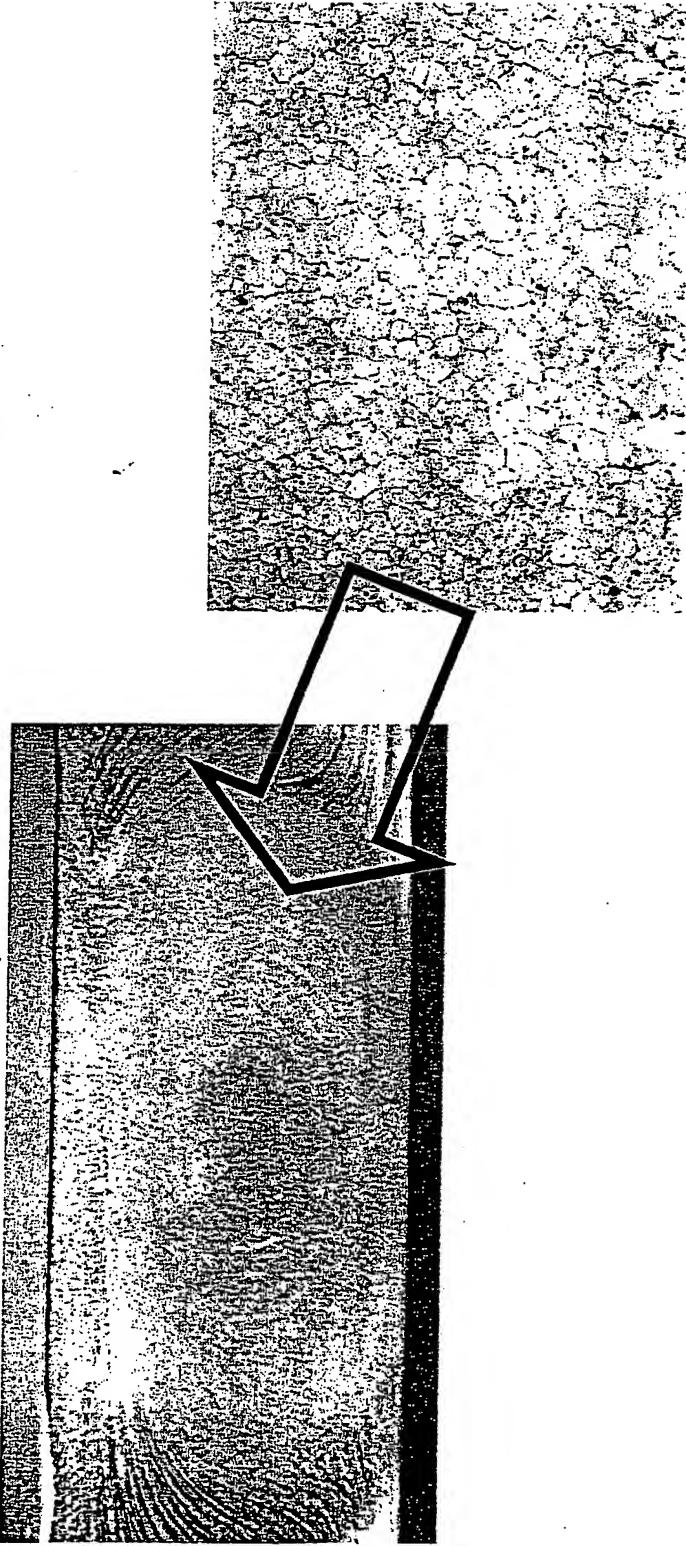
Edward Litwinski  
(Signature)

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- 1 copy of completed form to U.S. Patent Administrator
- 1 copy of completed form to Patent Engineering
- 1 copy of completed form plus any attachments to outside law firm, if applicable

*Highly Deformable, High Strength Rivets*

*The nugget of a FSW has a very fine grain structure*

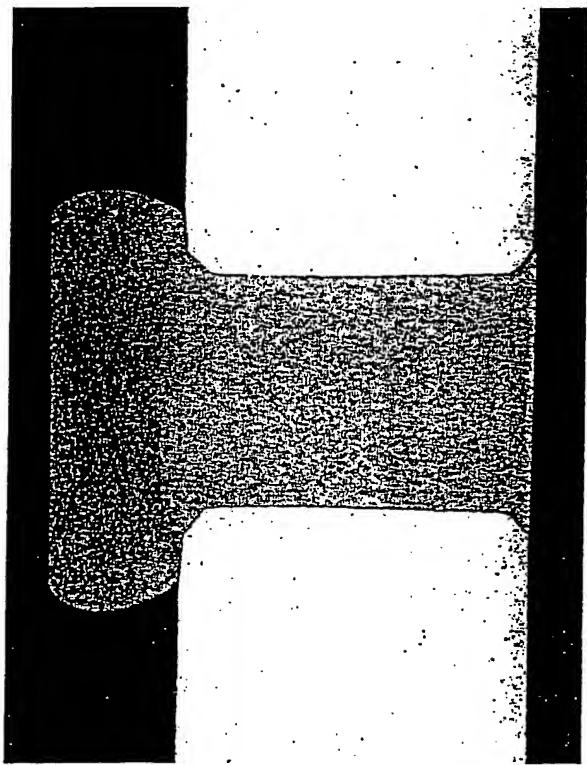


Fine grain size is known to increase toughness, fatigue strength and corrosion resistance.



# Conventional Rivet Technology

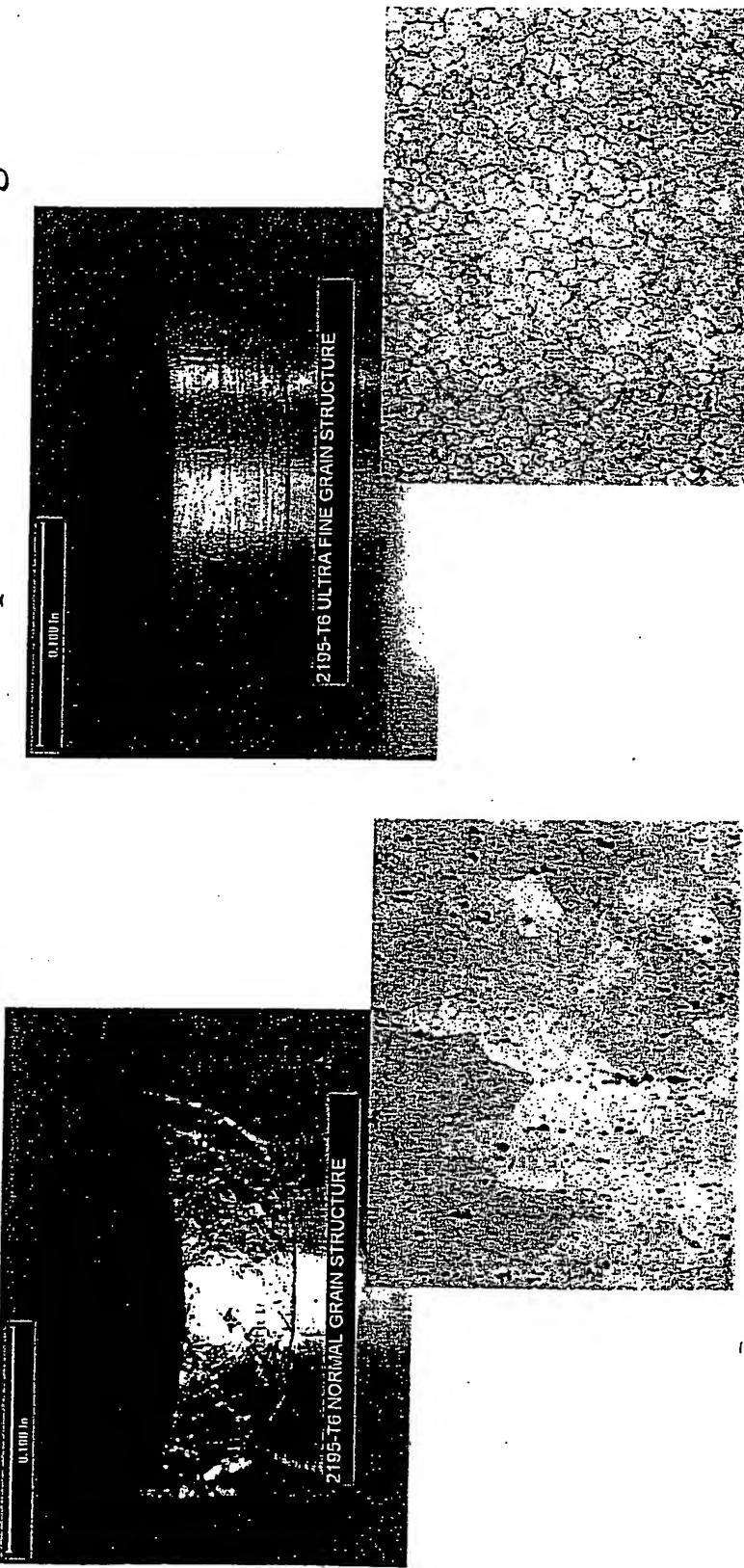
- Rivet materials had been chosen due to their ability to “upset” without cracking. The 2117-T4 alloy has been the conventional rivet alloy of choice.
- The increase in its ability to upset is related to its lack of strength



2117-T4 Material

# Conventional Al-Li Alloys

- Al-Li alloys are high strength alloys with reduced weight (approximately 4.5% less). However, the higher strength does not allow the alloy to “upset” without cracking.
- The fine grain FSW nugget material can upset without cracking.



2195-T6 Material

2195-T6 (FSW) Material

# Traditional Rivet Alloy Properties

- The 2195-T6 (FSW) material has better properties than conventional rivet materials.
- The process was not optimized. It is expected that with process improvements the properties could be improved to exceed conventional alloy properties with improved “upset”, toughness, fatigue and corrosion properties.

Alloy Data Summary					
Alloy	Weight, lbs/in <sup>3</sup>	Ult. Tensile, ksi	Yield Strength, ksi	%Elongation	Shear, ksi
2195-T6 (FSW)	0.097	Not Available	Not Available	Not Available	38.41
2195-T6	0.097	73	66	10	45
2017-T4	0.101	62	40	22	38
2117-T4	0.099	43	24	27	28
7050-T7	0.102	74	65	13	41
7075-T7	0.101	73	63	13	37

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